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(54) IMPROVEMENTS IN OR RELATING TO TANK STRUCTURES

(71) We, CONCH INTERNATIONAL METHANE LIMITED, a Bahamian Company of Boulevard House, Thompson Boulevard, Nassau, The Bahamas, formerly of Columbus House, Shirley Street, Nassau, The Bahamas, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to tanks for the storage or transportation of liquids in large volume and at a temperature differing widely from ambient temperature.

The invention is primarily intended for tanks for storing very cold liquids, such as liquefied gases, e.g., liquefied petroleum gases such as butane and ethylene, or liquefied natural gas at or near atmospheric pressure, in transportation means such as a marine tanker, which tanks are of so called "self-supporting type" that is, a tank which, when supported from beneath, is capable of withstanding its own weight, the weight of the liquid to be contained therein and inertia forces during transportation, without depending upon external means, such as the structure of the tanker itself, for aid in support of the walls of the tanks against buckling.

One form of self-supporting tank is known which is generally of prismatic shape and is flat sided; it will be readily appreciated that such a shape of tank is advantageous from the viewpoint of the tank capacity that can be installed in a marine tanker, which is itself generally flat sided and provided with internal flat transverse bulkheads or cofferdams. However in designing such a flat-sided tank for large volumes of liquids, difficulties arise in the provision of means for providing sufficient structural strength for service as a self-supporting tank. The difficulties are further aggravated by (1) the roll and pitch of the ship which creates unbalanced pressure in one or other of the walls of the tank, and (2) the thermal gradient which exists throughout the depth of the tank, especially when the latter is only partially filled with liquid at a temperature widely differing from ambient temperature. Thus, either a large number of horizontal beams are required or, if these are reduced in number, the thickness of the flat-sides must be increased. In either case the resulting tank provides a relatively heavy structure.

Self-supporting tanks have normally been constructed separately from the tanker, and, when assembled, mounted in the cargo holds of the tankers. However, the current trend is towards larger-capacity tankers and for simplicity and economy these require larger sized tanks rather than a greater number of small tanks. The large tanks of the flat-sided design present the difficulty that, being relatively heavy, the size of a tank which can be pre-assembled and then mounted in a tanker is limited by the loading capacity of shipyard cranes. It is, therefore, desirable to adopt a design of tank which is lighter in weight.

Moreover, large self-supporting tanks are exceedingly expensive, as ordinary steel is not suitable due to embrittlement at the low temperatures involved, and expensive materials must be used, so that it is important to minimize the amount of metal employed, while maintaining the desired necessary structural strength.

An object of the invention is to provide a self-supporting tank which is lighter than a flat-sided design for any given capacity while maintaining the necessary structural strength.

According to this invention. in a self-supporting tank of generally prismatic shape the vertically extending walls thereof are constructed from part-cylindrical sections joined together along lines extending horizontally of the tank, said lines between the sections of each wall being at corresponding heights, internal reinforcement plates are provided at each said line, which plates extend horizontally and substantially continu-

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ously around the interior of the tank, and each said line between pairs of adjacent sections and their reinforcement plates is provided by a joint in the form of a three-legged section, each leg being welded to the appropriate section or plate.

Preferably, the reinforcement plates extend a distance into the tank whereby substantially all the structural strength is provided by the curvature of the sections and the plates, thereby leaving the interior of the tank substantially free from other reinforcing members.

If required one or more flat bulkheads may be provided within the tank, thus dividing the tank into compartments, in which case the top and bottom walls of the tank may be connected by the or each bulkhead, the latter serving to provide structural strength to the tank in the vertical direction. The or each bulkhead may be stiffened by horizontal reinforcing members. Conveniently, these reinforcing members may be arranged to correspond in height with said reinforcement plates and may form part of or be connected to the latter.

According to a feature of the invention, the top and/or bottom walls of the tank may also be in the form of part-cylindrical sections which are joined together along lines preferably extending in the intended longitudinal direction of the tank, i.e., said lines are parallel with the longitudinal centreline of the tanker with the tank installed therein. With such an arrangement, the "two-way corners" of the tank in the longitudinal direction are provided by cylindrical sections subtending an angle in excess of 90°, whilst the "three-way corners" are provided by fitted part-spherical sections.

Each three-legged section for the bottom wall of the tank may include a further leg in the form of a girder adapted to extend externally of the tank, and vertically thereof, for supporting the bottom wall clear of its support surface.

In order that the invention may be readily understood and further features made apparent, two embodiments of tank constructed in accordance therewith for use in a liquefied natural gas marine tanker, together with modifications, will now be described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 is a transverse half-section of the first tank embodiment,

Figure 1A is a modification of the tank of Figure 1,

Figure 2 is a plan view of the second tank embodiment,

Figure 3 is a transverse section through the tank of Figure 2 and through the hull of the marine tanker in which it is located,

Figure 4 is a section on the line IV—IV of Figures 2 and 3,

Figure 5 is an enlarged detail of the part indicated by Arrow "A" in Figure 3,

Figure 6 is an enlarged detail of the part indicated by Arrow "B" in Figure 3, and

Figure 7 is an enlarged detail of the part indicated by Arrow "C" in Figure 3.

Referring to Figure 1 of the drawings the tank which is made of a metal such as aluminium alloy or 9% nickel -steel, which remains ductile at the temperature of the liquefied natural gas i.e., around —161°C, is generally of prismatic form. The tank has flat top and bottom walls 1, 2 respectively which are reinforced by spaced I-section girders 3. Each girder is provided with strengthening plates 4 for ensuring that the web of the girder remains normal to the plane of its wall. In the Figure, only one external vertically extending wall of the tank is shown at 5 and also as shown, this wall includes a chamfered portion 6 at its lower end, for fitting into a correspondingly shaped cargo hold of the marine tanker, for example, as shown in Figure 3. This wall 5, as well as the three other vertically extending external walls, is constructed from nine part-cylindrical sections 7, that is, sections the curvature of which subtends an angle substantially less than 180°. The sections 7 are joined together along lines 8 extending horizontally of the tank and are reinforced along these lines by reinforcement plate girders 9. The tank of this embodiment is provided with a centreline bulkhead 10, dividing the tank into two compartments, which is connected to the top and bottom walls 1, 2 and provides a structural member for assisting in supporting the top wall 1 of the tank. The bulkhead 10 is also provided with girders 11 which are at corresponding heights to the heights of the girders 9 of the external walls, and said girders 9 and 11 are connected together whereby to provide continuous support around the tank walls and bulkhead. In the modification shown in Figure 1A, the part-cylindrical sections 7 are wider and shallower than those of Figure 1, thus resulting in a reduction in the number of horizontal plate girders 9; in this modification four are provided. However, it would be necessary with this modification to provide thicker wall sections than those required for the Figure 1 arrangement.

Referring now to Figures 2 to 4, like parts to those described in Figure 1 are given the same reference numbers.

The second embodiment of the tank is of multicylinder form in that it is provided with part-cylindrical sections for the top and bottom walls 1, 2 respectively in addition to the vertically extending walls. Thus, the top and bottom walls comprise part-cylindrical sections 7 which are joined along lines 12 extending longitudinally of the tanker 13

when installed in its cargo hold 14. As is well known with liquefied gas tankers, the cargo holds 14 are defined normally by an inner hull 15 and spaced cofferdams (not shown). As shown particularly in Figure 3, the two-way corners of the tank in the longitudinal direction are provided by cylindrical sections 16 which subtend an angle greater than 90°, these sections being joined along their edges with the sections 7 of the vertically extending walls of the tank, and in the longitudinal direction with the sections 7 of the top and bottom walls. In the transverse direction the two-way corners are provided by upper sections similar to sections 7 of the vertically extending walls interfitted into the ends of sections 7, 16 of the top wall 1 as shown in Figures 2 and 4. The three-way corners of the tank are completed by fitted part-spherical sections 17 as shown in Figure 2. The joint lines 12 of the sections 7 and 16 of the top wall 1 of the tank, as well as the joint lines 8 of the vertically extending walls, are strengthened by internal girders in a manner similar to that described for the vertically extending walls of the tank of Figure 1. However, in the case of the bottom wall 2 of the tank, additional external girders 18 are provided for supporting said bottom wall clear of the floor of the cargo hold 14. Said girders 18 are supported on support members 19 which, for the transverse and longitudinal centre lines of the tank, incorporate suitable keys to restrain sliding movement of the tank. The support members 19 are provided on a drip tray 20, preferably of the same metal as the tank, extending beneath the bottom wall 2 of the tank and intended for catching leaking carbo should the tank rupture for any reason. It has been found that for self-supporting tanks of ductile material, should a rupture occur, crack propagation is sufficiently prolonged for a drip tray to contain the leak for at least the duration of the voyage and perhaps for several voyages until repairs can be carried out. The drip tray 20 rests on thermal insulation 21 which, if required to satisfy ship classification socety regulations, may incorporate a full secondary barrier against leakage of cargo, the primary barrier being provided by the tank itself. Thus, for example, the thermal insulation may be as described in the specification of our British Patent No. 1,203,496 wherein polyurethane foam is sprayed in layers into openings provided by a balsa wood frame around the perimeter of the vertically extending walls and a load-bearing balsa wood floor is provided for the tank. Alternatively, the floor may also be lined with sprayed layers of polyurethane foam between islands or lines of load-bearing balsa wood panels, for example, as described in our co-pending British Patent Application No. 48749/70 (Serial No. 1,300,730).

In the present embodiment it is assumed that the thermal insulation is not required to provide a secondary barrier and, with reference to Figure 5, the thermal insulation comprises layers 22 of fibrous glass, which for at least the vertically-extending walls of the tank, includes within its thickness a vinyl or aluminium foil impingement barrier providing a continuous surface for directing any liquid leaking from the tank into the drip tray. To facilitate this, the layers 22 are carried by the vertically extending walls of the tank rather than the corresponding walls of the cargo hold 14 and the bottom edges of these layers locate into a groove provided between the rim of the drip tray 20 and said tank walls.

Referring to Figure 6, the joint between the sections 7 and 9 and the girders 8 may be provided by a three-legged extruded section 23 of metal, the component parts of the joint being butt-welded to the appropriate legs of the extrusion.

As shown in Figure 7, similar extruded sections 23 may be used for the bottom wall 2 of the tank and incorporating further legs 24 for the additional bottom support girders 18.

WHAT WE CLAIM IS:—

1. A self-supporting tank of generally prismatic shape, wherein the vertically extending walls thereof are constructed from part-cylindrical sections joined together along lines extending horizontally of the tank, said lines between the sections of each wall being at corresponding heights, internal reinforcement plates are provided at each said line, which plates extend horizontally and substantially continuously around the interior of the tank, and each said line between pairs of adjacent sections and their reinforcement plates is provided by a joint in the form of a three-legged section, each leg being welded to an appropriate section or plate.

2. A self-supporting tank according to Claim 1, wherein the reinforcement plates extend a distance into the tank whereby substantially all the structural strength is provided by the curvature of the sections and the plates, thereby leaving the interior of the tank substantially free from other reinforcing members.

3. A self-supporting tank according to Claim 1 or Claim 2, wherein the tank has one or more internal bulkheads, the or each bulkhead extending between the top and bottom walls of the tank and being connected to said walls whereby to provide structural strength to the tank in the vertical direction.

4. A self-supporting tank according to

Claim 3, wherein the or each bulkhead is stiffened by horizontal reinforcement members which are arranged to correspond in height with said reinforcement plates, said members forming part of or being connected to the latter.

5. A self-supporting tank according to any one of Claims 1 to 4 for a marine tanker, wherein the top and/or bottom wall of the tank is also in the form of part-cylindrical sections which are joined together along lines extending in the intended longitudinal direction of the tank.

6. A self-supporting tank according to Claim 5, whereon the "two-way corners" of the tank in the longitudinal direction are provided by cylindrical sections subtending an angle in excess of 90°, whilst the "three-way corners" are provided by fitted part-spherical sections.

7. A self-supporting tank according to any one of the preceding claims, wherein each three-legged section is an extension.

8. A self-supporting tank according to any one of the preceding Claims and having its bottom wall formed of part-cylindrical sections, wherein each three-legged section for said bottom wall includes a further leg in the form of a girder adapted to extend externally of the tank, and vertically thereof, for supporting the bottom wall clear of its support surface.

9. A self-supporting tank according to Claim 8, wherein said further legs form part of a drip tray extending beneath said bottom wall.

10. A self-supporting tank according to Claim 9, wherein a plurality of insulation layers are provided on the vertically extending walls of the tank, said layers including an impingement barrier, and the bottom edges of said layers are located between the rim of the drip tray and said walls of the tank.

11. A self-supporting tank for a marine tanker constructed, arranged and adapted for use substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

12. A self-supporting tank according to Claim 11 modified substantially as hereinbefore described with reference to Figure 1A of the accompanying drawings.

13. A self-supporting tank for a marine tanker constructed, arranged and adapted for use substantially as hereinbefore described with reference to Figures 2 to 7 of the accompanying drawings.

14. A marine tanker for very cold liquids having located therein at least one self-supporting tank according to any one of the preceding Claims.

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3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

FIG.1.

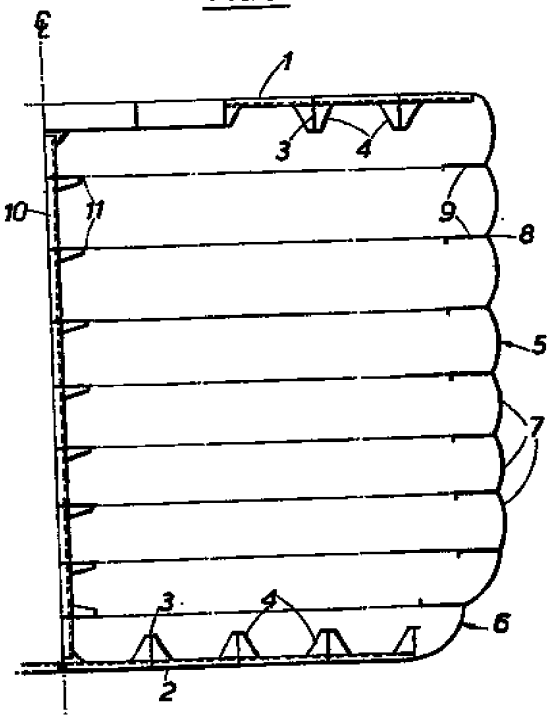

FIG.1A.

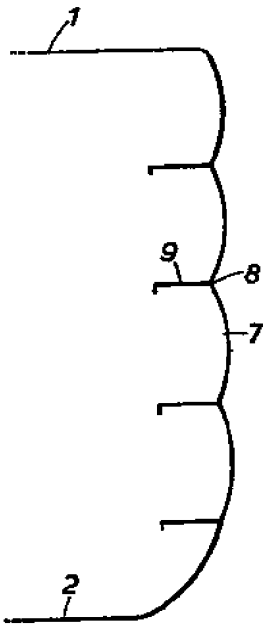

FIG.2.

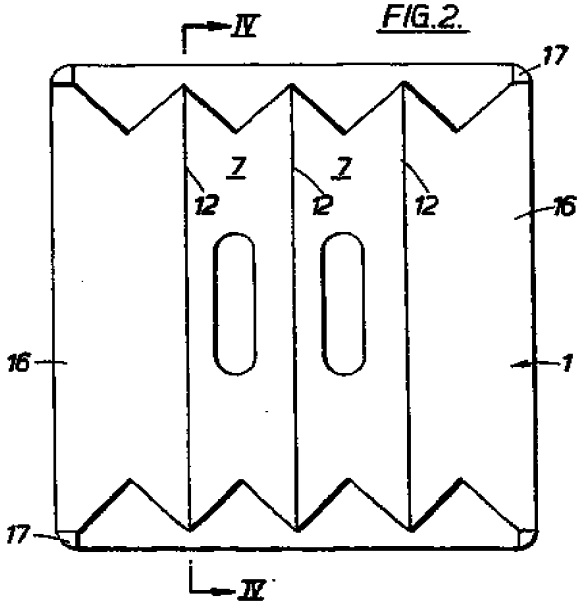

FIG.3.

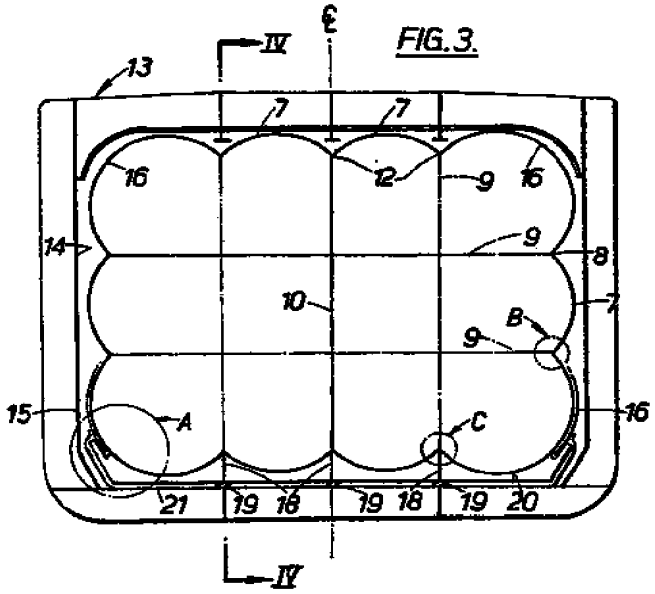

FIG.4.

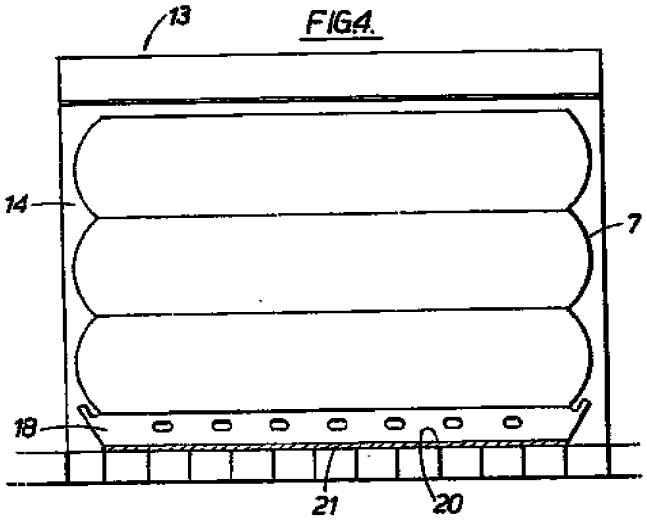

FIG.5.

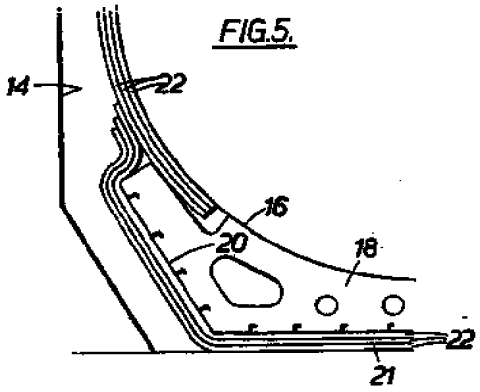

FIG.7.

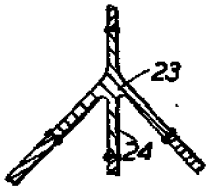

FIG.6.